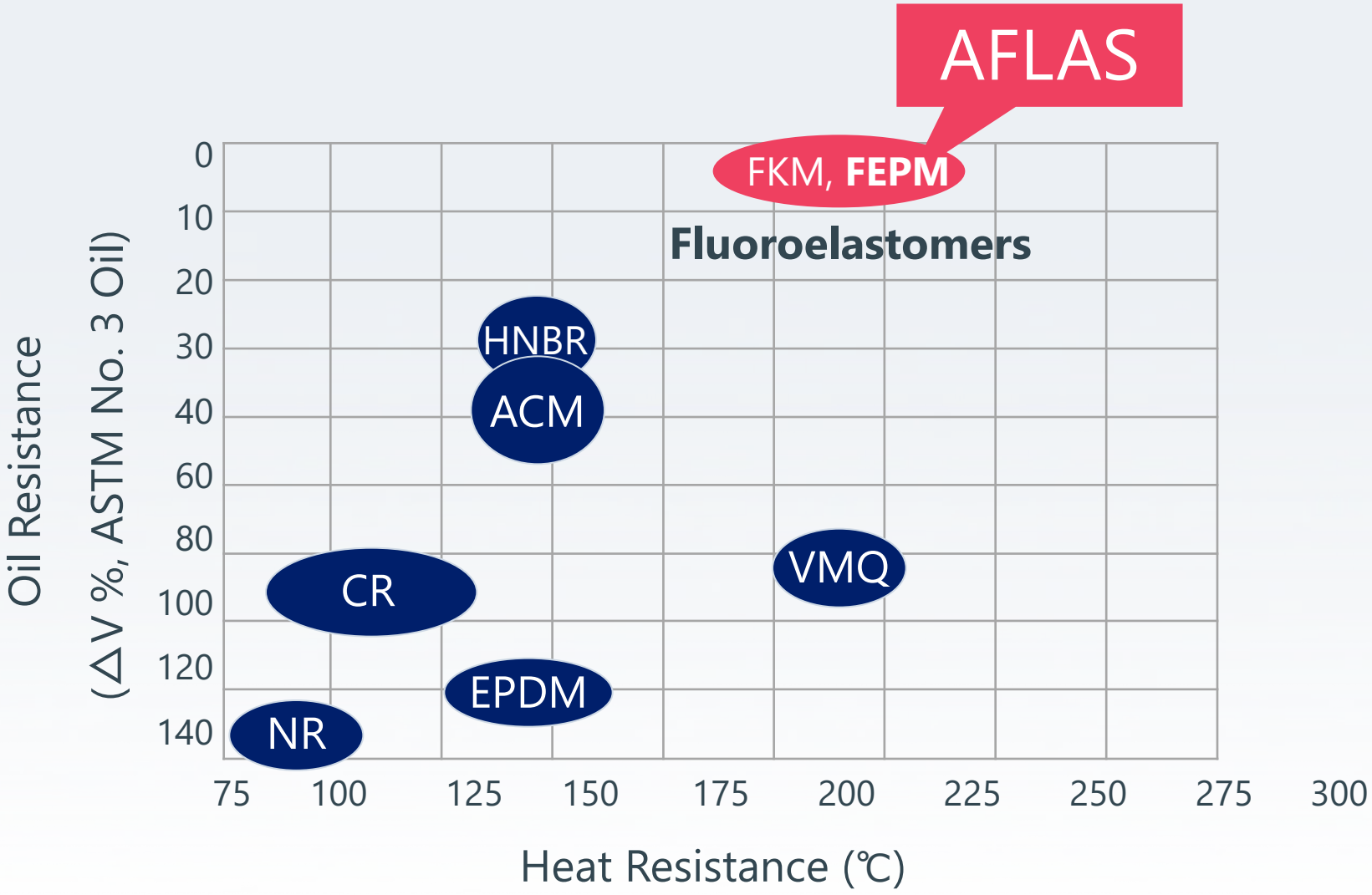
Introduction to AFLAS® 400E and 600X Fluoroelastomers

AGC

AFLAS®
FLUOROELASTOMERS

Your Dreams, Our Challenge

Positioning Map of Fluoroelastomers



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Polymer Structure

FEPM = AFLAS TFE-P

$$-(CF_2\text{-}CF_2)_p\text{-}(CH_2\text{-}CH(CH_3))_q-$$

TFE Pr

FKM = Viton, etc.

$$-(CH_2\text{-}CF_2)_l\text{-}(CF_2\text{-}CF(CF_3))_m\text{-}\ -(CF_2\text{-}CF_2)_n-$$

VdF HFP TFE

Deterioration by Base

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AFLAS® 400E and 600X Grades

Differences from conventional AFLAS:

- Improved compression set
- Faster cure speed
- Improved mold release
- White base resin color
- Same characteristics: resistance to bases, steam, ED, sour gas; electrical resistance, but same Tg

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AFLAS 400E and 600X Grades Concept

Conventional AFLAS

- Relatively slow cure time
- Dark polymer color

400E and 600X

- Faster cure, improved compression set
- White, improved processing

	400E	600X
Application	Extrusion	Molding
Appearance	White	White
Cure system	Peroxide	Peroxide
Specific Gravity	1.55	1.55
Storage Modulus G' (RPA, 100 ℃, 1Hz, 0.5 deg)	280	350

1. **AFLAS® 400E**

2. **AFLAS® 600X**

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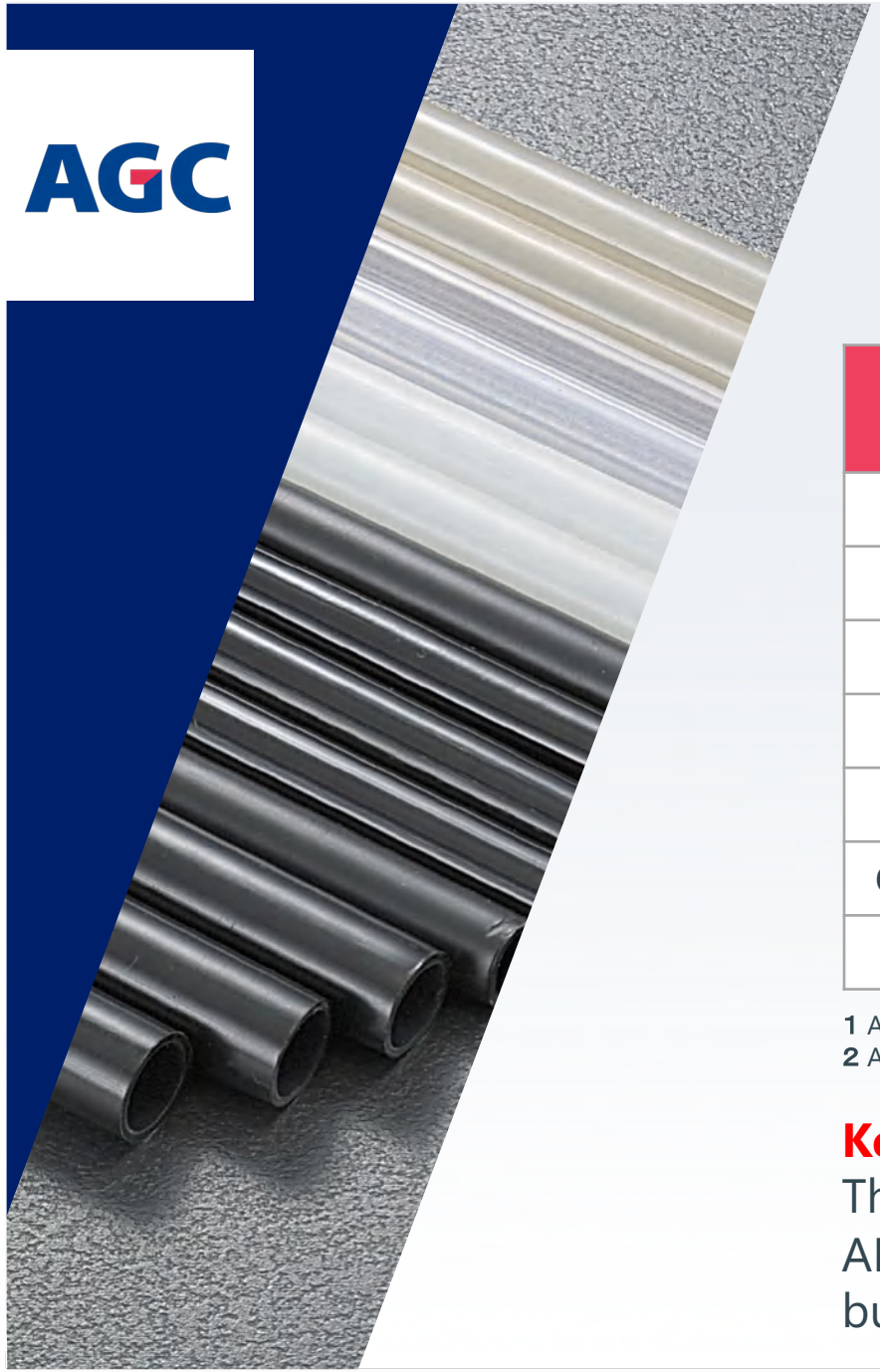


AFLAS 400E vs. 150E: Shore A Hardness 70

	Compound A	Compound B	Conventional AFLAS 150E
AFLAS 400E	100	100	150E:100
N-990 Carbon	30	30	30
TAIC	5	5	5
Perkadox 14[1]	1.5	-	1
Luperox 101[2]	-	1.5	-
Calcium Stearate	1	1	1
Processing Aid	2	2	2

1 Akzo Nobel, 1,3-Bis(t-butyl peroxy isopropyl)benzene
2 Arkema, 2,5-Dimethyl-2,5-di(t-butyl peroxy)hexane

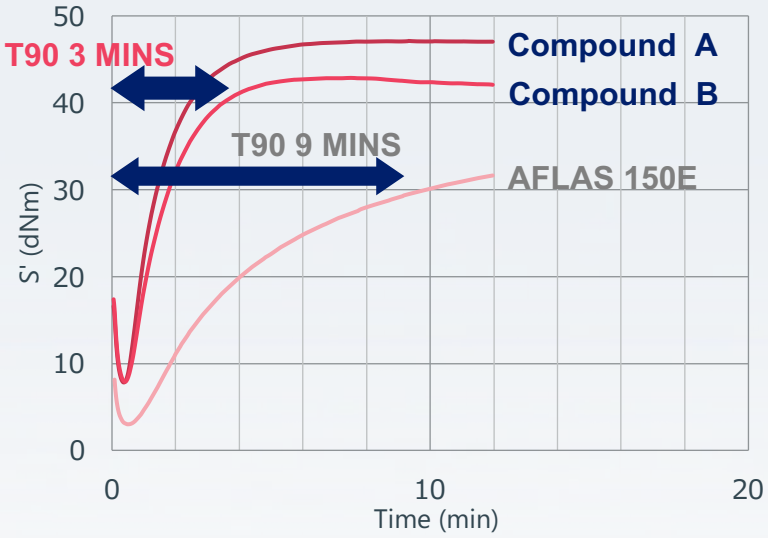
Key Point

There **is greater flexibility with peroxide selection**—standard AFLAS needs specific peroxides that are different from FKM types, but 400E can be used with either type.

400E: Cure Characteristics

RPA 2 Hz, 3 deg.

Temperature 170 ℃



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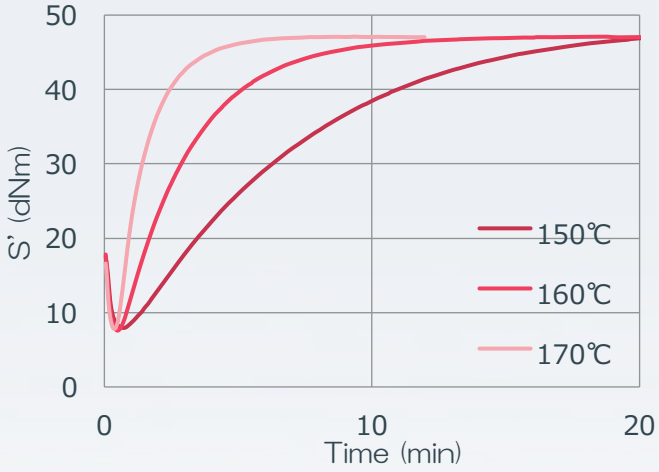
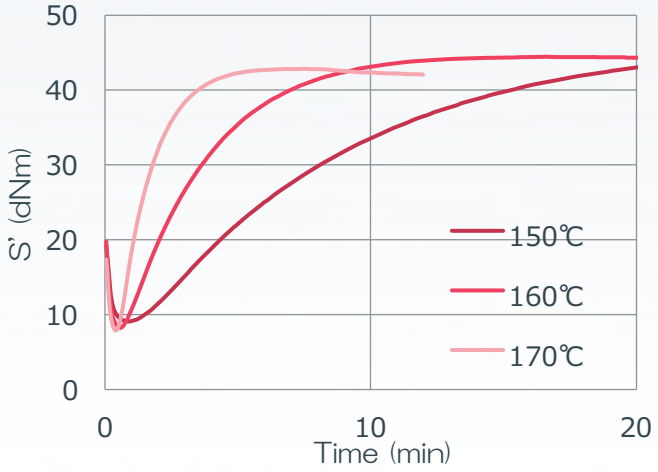
	AFLAS 400E Compound A	AFLAS 400E Compound B	AFLAS 150E
150 ℃	14.9	17.7	25.4
160 ℃	6.7	7.5	–
170 ℃	3.2	3.3	8.7

Rapid Cure

Compound A – Effect of Temp.



Compound B – Effect of Temp.



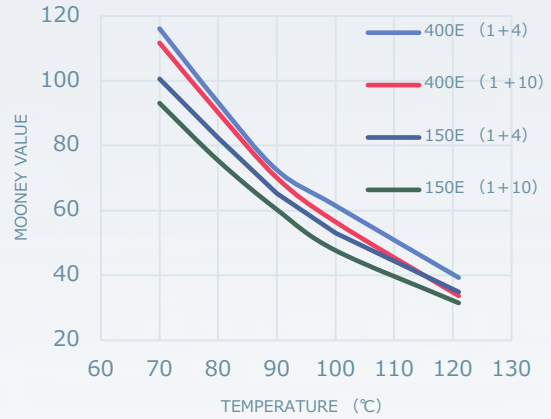
AFLAS 400E: Physical and Electrical Performance

Cure: 170 ℃ x 10 min press
220 ℃ x 4 hr post cure

Physical		Comp. A	Comp. B	AFLAS 150E*
Mooney Value 121 ℃	1+ 4 1+10	39 34	39 34	35 32
Tensile Strength	MPa	12	11	12
100% Modulus	MPa	5	5	5
Tensile Elongation	%	490	520	310
Hardness	Shore A	73	71	70
Specific Gravity	-	1.6	1.6	1.6

* 170 ℃ × 20 min press

Viscosity



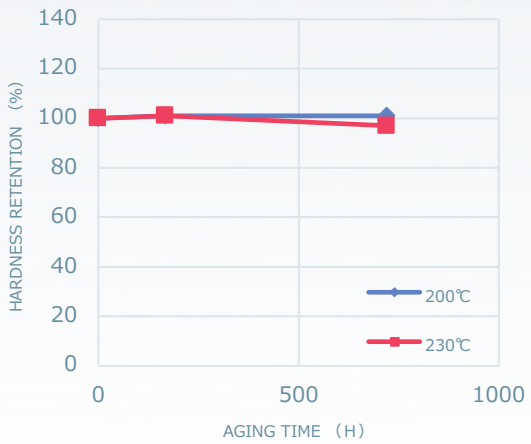
Electrical		AFLAS 400E	FKM	Silicone Rubber
Volume Resistivity	Ω.cm	3 x 10^{16}	2 x 10^{13}	5 x 10^{15}
Dielectric Constant	1 kHz	2.8	10	3–4
Dielectric Loss Tangent	1 kHz	0.03	0.03	0.007
Dielectric Breakdown	kV/mm	23	20	25

AFLAS 400E: Thermal Resistance

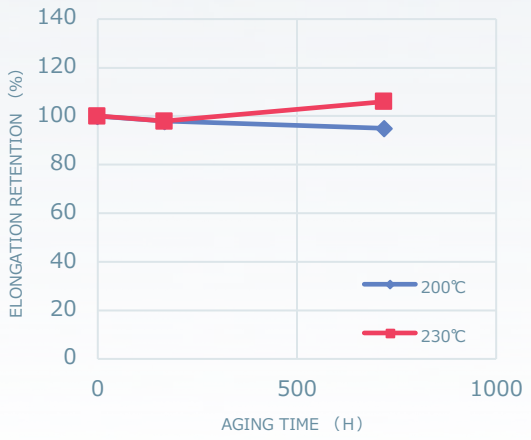
Long-Term Thermal Resistance – 720 hours

	200 ℃	230 ℃
Hardness Change (points)	1	-2
Elongation Change (%)	-5	6
Tensile Strength Change (%)	15	3

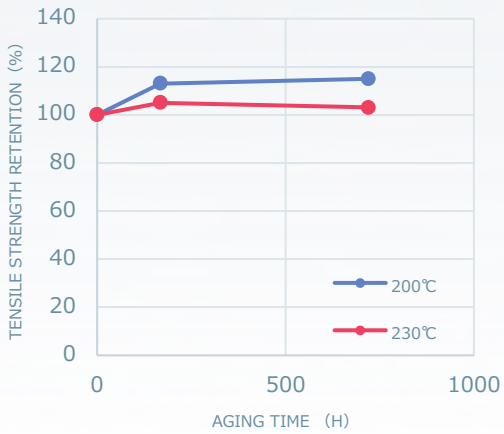
Hardness



Elongation



Tensile Strength



AFLAS 400E: Chemical Resistance

Base Resistance

	Immersion temp (℃)	168 h Volume Change (%)		720 h Volume Change (%)	
NaOH（48%）	70	0.1	A	0.1	A
Ethylenediamine	25	1.4	A	2.9	A
Aq. Ammonium (28%)	70	3.3	A	6.3	B

170 ℃ Steam Resistance

	168h	720h
Hardness Change (points)	-2	-2
Elongation Change (%)	-10	-14
Tensile Strength Change (%)	3	3

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AFLAS 400E: Extrusion Performance

Extrusion Property	Finish
Swell at die	Excellent
Sharp edge	Excellent
Surface smoothness	Excellent
Corner stability	Excellent

Conditions of the test

- Hardness Shore A: 70
- 40 mm single-screw extruder
- Temperature
  - Head 70 ℃
  - Die 70 ℃
  - Extruder cylinder 65 ℃
- Throughput: 16 kg/h

1. Tube OD 6 mm, ID 4 mm

2. Shaped extrusion

1. AFLAS® 400E

2. AFLAS® 600X

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AFLAS 600X Standard Compound vs. FKM Terpolymer

	Compound A	Compound B
AFLAS 600X	100	100
N-990 Carbon	30	30
TAIC	3	3
Perkadox 14[1]	1	-
Luperox 101[2]	-	1
Calcium Stearate	1	1

Conventional AFLAS 150P	FKM Terpolymer
100	100
30	20
5	4
1	-
-	1.5
1	-

1 Akzo Nobel, 1,3-Bis(t-butyl peroxy isopropyl)benzene
2 Arkema, 2,5-Dimethyl-2,5-di(t-butyl peroxy)hexane

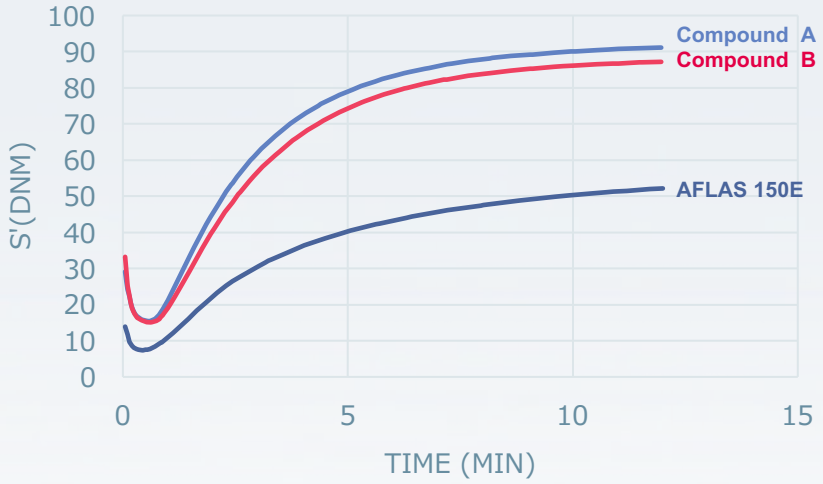
Key Point

There is **greater flexibility with peroxide selection**—standard AFLAS needs specific peroxides that are different from FKM types, but 600X can be used with either type. Plus, 600X has reduced TAIC.

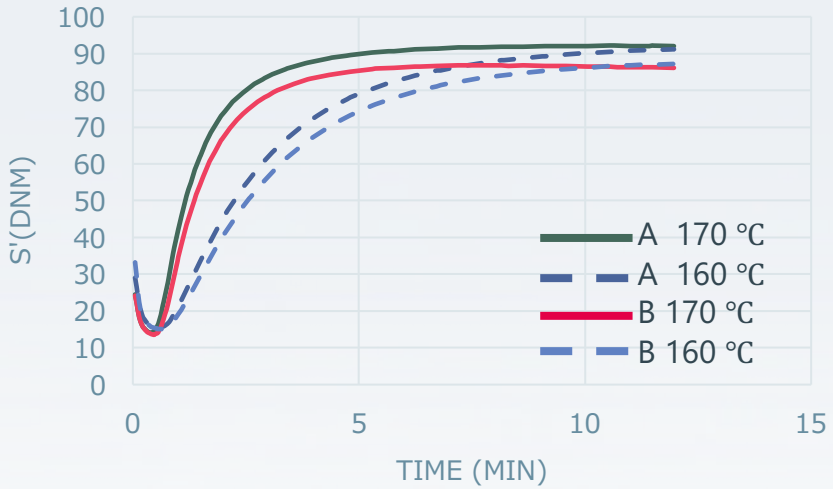
600X: Cure Characteristics

RPA 2 Hz , 3 deg.

Temperature 170 ℃



Effect of Temperature
160 ℃–170 ℃



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	AFLAS 600X Compound A	AFLAS 600X Compound B	AFLAS **150E**
160 ℃	6.1	6.3	NA
170 ℃	3.1	3.1	10.8
180 ℃	1.6	1.6	NA

Rapid Cure

600X: Physical and Electrical Performance

Cure: 170 ℃ x 10 min press
220 ℃ x 4 hr post cure

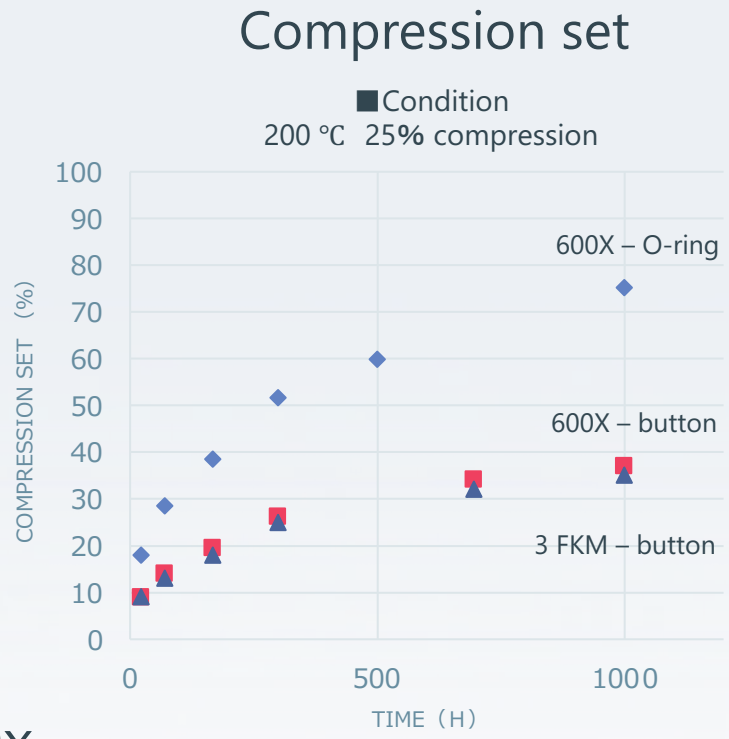
	AFLAS 600X Compound A	AFLAS 600X Compound B
ML 1+4	98	97
ML 1+10	96	95

Conventional AFLAS 150P	FKM Terpolymer
62	19
57	16

Physical Properties		AFLAS 600X Compound A	AFLAS 600X Compound B
Tensile Strength	MPa	23	21
100% Modulus	MPa	6	5
Tensile Elongation	%	220	250
Hardness	Shore A	70	70
Specific Gravity	-	1.6	1.6
Compression Set	%	29	30

AFLAS 150P	FKM Terpolymer
15	20
5	3
290	290
72	71
1.6	1.9
46	30

600X: Improved Compression Set



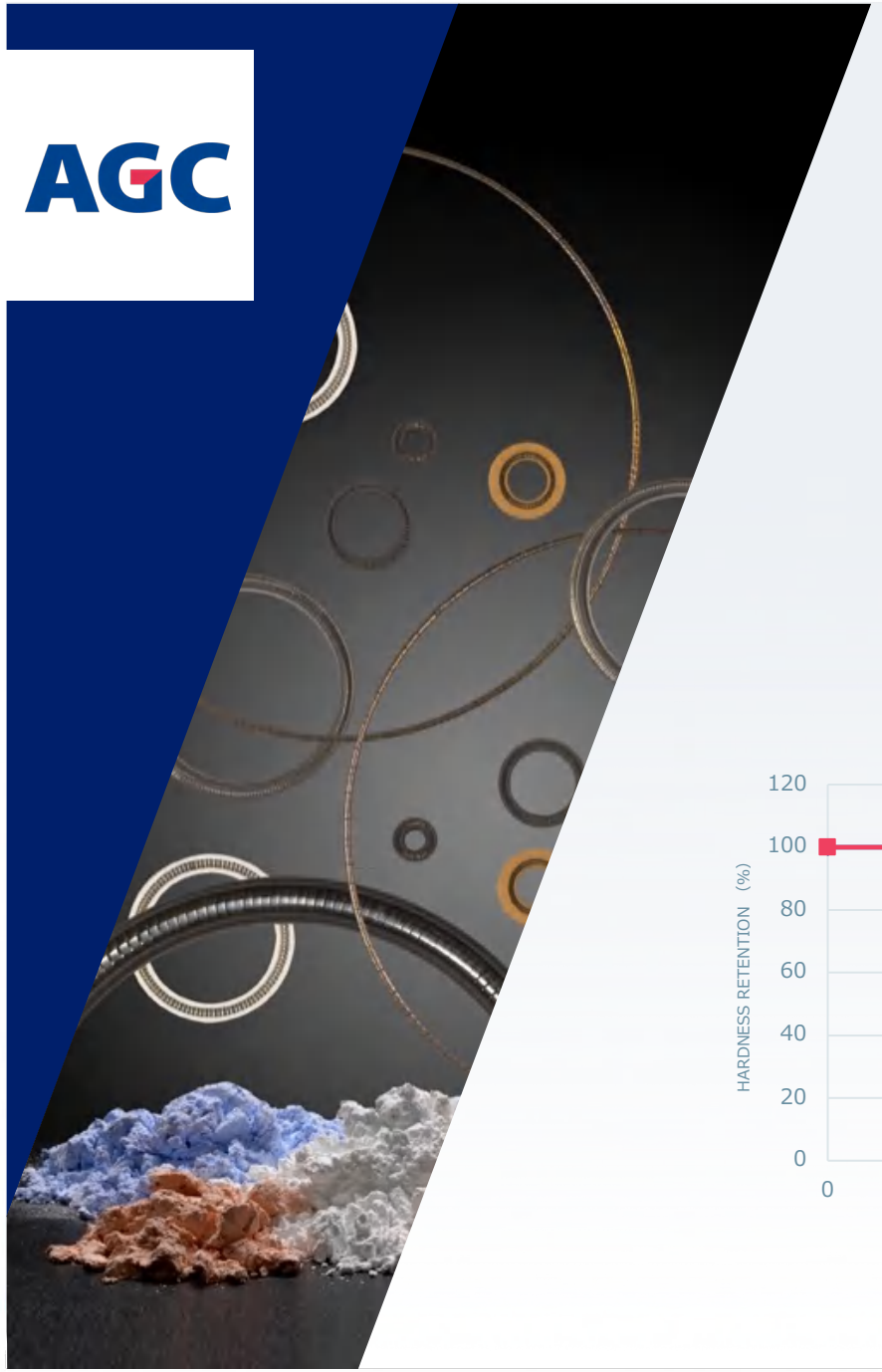
Reference
Conventional AFLAS 100S

O-ring	33	46
Button	20	29

600x

	22h	70h	168h	700h	1000h
O-ring	18	29	39	65	75
Button	9	14	19	34	37

Excellent Compression Set

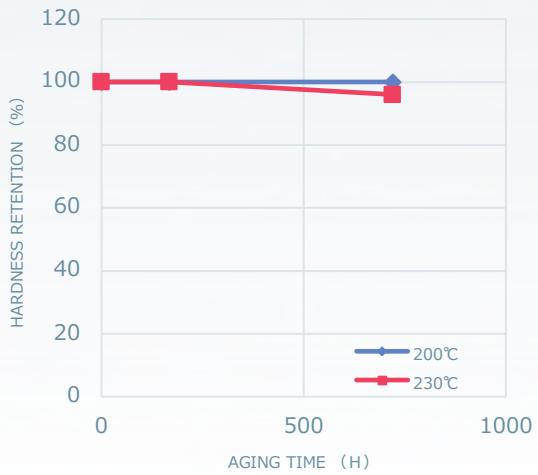


600X: Thermal Resistance

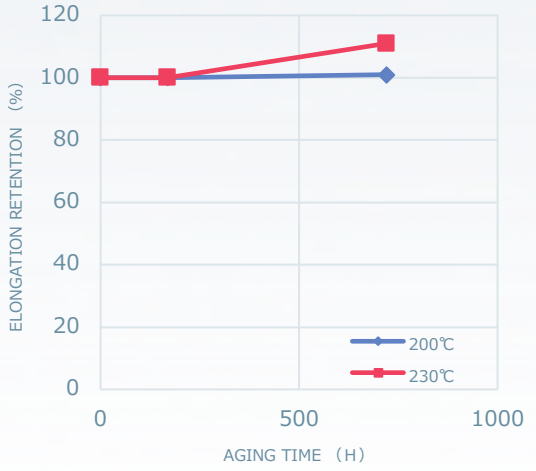
Long-Term Thermal Resistance – 720 hours

	200 ℃	230 ℃
Hardness Change (points)	0	-3
Elongation Change (%)	1	11
Tensile Strength Change (%)	11	-12

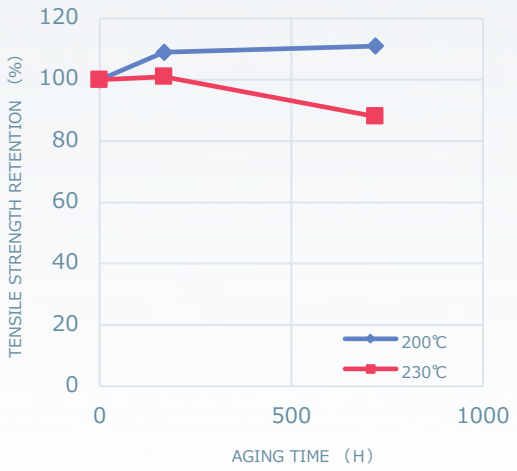
Hardness



Elongation



Tensile strength



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AFLAS 600X: Steam Resistance

Steam and Hot Water resistance – 720 hours

	Immersion Temperature (℃)	168 h Volume Change (%)		720 h Volume Change (%)	
Hot Water	40	0.1	A	0.3	A
	80	0.1	A	0.4	A
Steam	170	1.2	A	2	A

170 ℃ Steam Resistance – 720 hours

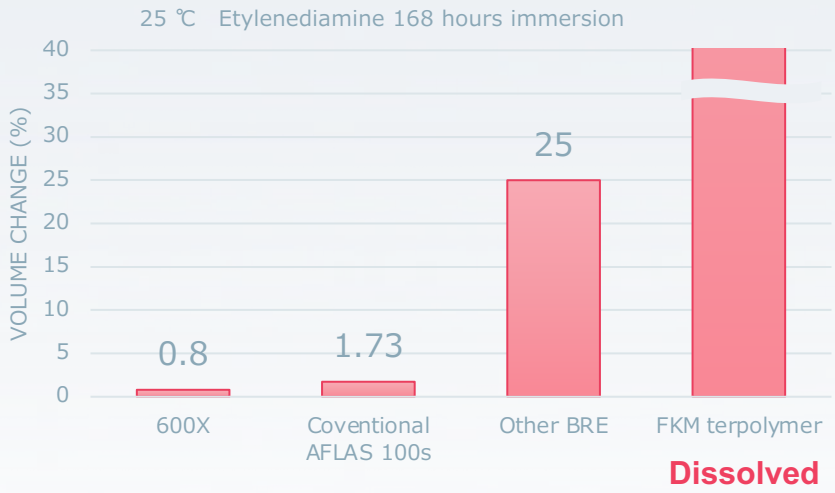
	168 h	720 h
Hardness Change (points)	0	-1
Elongation Change (%)	-7	-7
Tensile Strength Change (%)	-5	-7

AFLAS 600X: Chemical Resistance

	Temp. (℃)	168h Volume change (%)		720h Volume change (%)	
HCl（20%）	70	1.2	A	3.1	A
NaOH（48%）	70	0.1	A	0.4	A
Ethylene -diamine	25	0.8	A	1.5	A
Aq. Ammonium (28%)	70	1.3	A	2.7	A

Excellent Base Resistance

Comparison with BRE, FKM



Mold Release: AFLAS 600X vs. Conventional AFLAS

Conventional AFLAS

AFLAS 600X

Excellent mold release

Overview of Fast-Cure TFE-P AFLAS

- Excellent electrical resistivity
- Excellent thermal resistance
- Excellent resistance to bases and acids
- Colorable

AFLAS 400E
Good for extrusion

AFLAS 600X
Excellent compression set
Excellent mold release
Good for compression molding

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